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ABSTRACT

Ballistic helmets are designed primarily to protect the head against high-speed impact from fragmentation munitions. The Australian Defence Forces (ADF) have recently introduced into service a composite ballistic helmet. This ballistic helmet is similar in shape to the US Army PASGT helmet on which it is based. When designing these ballistic helmets scant attention was given to the thermal loading on the wearer. Laboratory trials however, have shown that some soldiers have experienced "hotspots" on the front of the head when wearing the ADF ballistic helmet in hot environments.

The ballistic helmet is an integral component of the personal armour system and must be worn when wearing a fragmentation or ballistic vest regardless of the environmental conditions. In order to reduce the thermal loading, venting of the helmet was proposed. This report examines airflows under a ballistic helmet and the effect of venting on thermal and vapour resistances using a sweating hotplate. From this work venting does not appear to provide an adequate solution to reducing the thermal load imposed by a ballistic helmet.

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Executive Summary

Ballistic helmets are designed primarily to protect the head against high-speed impact from fragmentation munitions. The Australian Defence Forces (ADF) have recently introduced into service a composite ballistic helmet. This ballistic helmet is similar in shape to the US Army PASGT helmet on which it is based. When designing these helmets scant attention was given to the thermal loading on the wearer. Laboratory trials by Egglestone and Amos have shown that some soldiers have experienced "hotspots " on the front of the head when wearing the ADF ballistic helmet in hot environments.

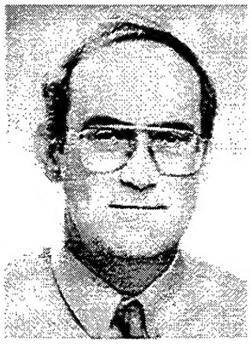
As the ballistic helmet is an integral component of the personal armour system and must be worn when wearing a fragmentation or ballistic vest regardless of the environmental conditions, venting of the helmet was examined as a mechanism for reducing its thermal burden.

Measurements of the resistance of heat (R_c) and moisture vapour (R_e) for the helmet laminate were made using a sweating hotplate as the heat source. These results indicated that the most effective means of reducing the thermal load was not by venting the laminate but by including an air gap that provided flow-through ventilation between the laminate and the heat source.

The sweating hotplate results were translated into practice by measuring the airflow under a helmeted manikin placed in low velocity airstreams. These results, like those from the sweating hotplate showed that in terms of thermal loading there is little benefit in venting the helmet unless a large amount of the helmet surface is removed. Most likely this would have an adverse affect on the integrity of the helmet and reduce its ability to provide the ballistic protection for which it was designed.

Members of the ADF intuitively thought that venting the ADF ballistic helmet with small vent holes would provide a large increase in wearer comfort. This has been shown to be unlikely given that little thermal benefit has been shown from a small amount of venting. A more suitable method for reducing the thermal burden imparted by a helmet is to encourage a larger airflow under the helmet and across the crown. Research into a more effective method for mounting the helmet on the head to assist this airflow would be more beneficial than venting the helmet.

Authors



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Graeme T. Egglestone has been employed at the Aeronautical and Maritime Research Laboratory since 1968. He graduated with a Diploma of Applied Science in 1975 from FIT and has completed an MSc from La Trobe University. He has extensive experience in the area of degradation and ballistic performance of polymeric materials and clothing comfort. in 1986-87 he was seconded to the US Natick Research Development and Engineering Center in Massachusetts where he researched the ballistic response of fibrous materials and composites. At present he is manager of a program on the personal protection of combatants.

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David J.Robinson has been employed at the Aeronautical and Maritime Research Laboratory since 1989. He graduated with an Associate Diploma in Applied Science in 1992 from Western Metropolitan College of TAFE. He has been closely involved with ongoing research into various aspects involved with the personal protection of combatants. This work has included flammability, clothing comfort, ballistic protection and signature management.

Contents

1. Introduction

Ballistic helmets are designed primarily to protect the head against high-speed impact from fragmentation munitions. The Australian Defence Forces (ADF) have recently introduced into service a composite ballistic helmet that is capable of stopping a 1.1g Fragmentation Simulating Projectile (FSP) at an impact velocity of 650 ms^{-1}. These helmets are moulded using an aramid fabric as the reinforcement and a phenolic resin as the matrix.

The ADF ballistic helmet is similar in shape to the US Army PASGT helmet on which it is based. When designing these ballistic helmets scant attention was given to the thermal loading on the wearer. Laboratory trials by Egglestone and Amos [1] have shown that some soldiers have experienced "hotspots " on the front of the head when wearing the ADF ballistic helmet during operations in hot environments. Figure 1 shows these hotspots on a soldier after completing 90 minutes of marching on a treadmill in an environmental chamber kept at 40°C and 30% Relative Humidity (RH). These environmental conditions were selected to simulate a climatic condition likely to be found in areas of northern Australia.

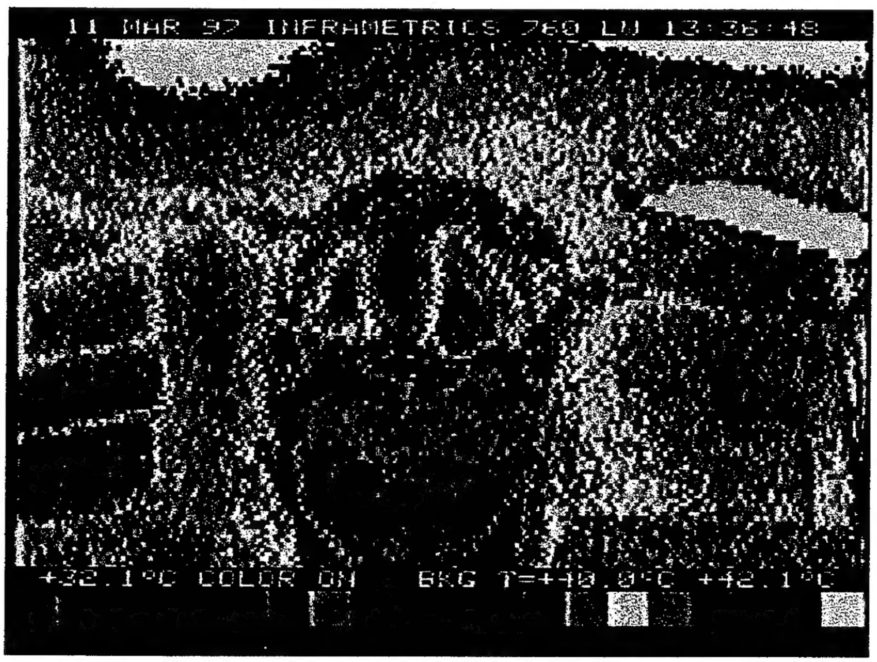


Figure 1 Hotspots caused by exercising in a ballistic helmet in a harsh environment

In hot operational environments cooling predominantly takes place as a result of sweat evaporation. Restriction of this evaporative loss increases the thermal burden. Although the head is less than 10% of the total body surface area its importance in efficient body cooling has been detailed by numerous studies [2,3,4]. This is due in part to the large vascular blood supply, which does not undergo vasoconstriction [2].

The ballistic helmet is an integral component of the personal armour system and must be worn when wearing a fragmentation or ballistic vest regardless of the

environmental conditions. Reducing the thermal load imposed by the helmet through venting in order to increase both convective and evaporative heat loss from the head was proposed.

In order to examine the thermal and vapour resistances imposed by a helmet a series of tests was undertaken using a sweating hotplate. A further series of tests was also undertaken to examine the effect vents would have on the airflow between a helmet and a manikin head.

2. Experimental

2.1 Sweating Hotplate

The fundamental properties of heat and moisture transfer were determined using a sweating hotplate manufactured by the S.E.A Engineering Company, Canada. The surface of the hotplate and guard ring were maintained at a temperature of 35 +/- 0.05°C, the power required to maintain the hotplate surface at this temperature was sampled each 5 seconds and a one-minute average was recorded. The test plate and guard ring temperatures were sampled and averaged at the same rate as the power input. A schematic of the hotplate is given as Figure 2.

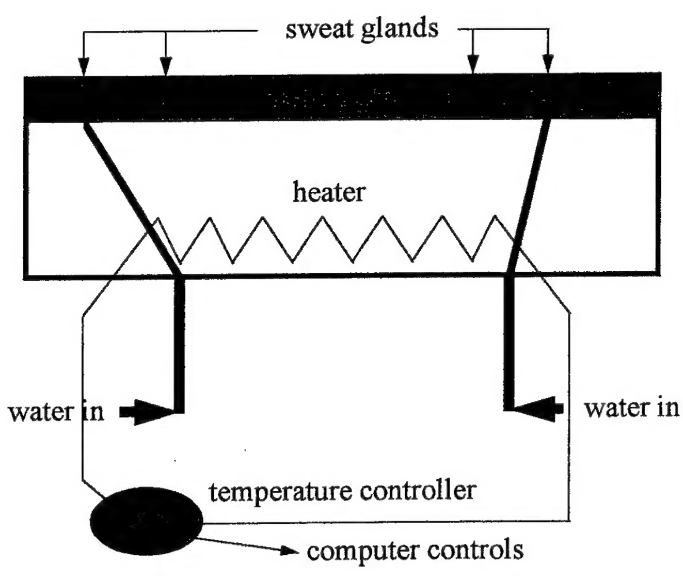


Figure 2 Schematic of the sweating hotplate

2.2 Thermal Resistance (R_c)

The thermal resistance (R_c) of the helmet laminate was measured using the sweating hotplate in the dry mode. The tests were conducted in accordance with ISO specification 11092-1993, except that the environmental condition within the chamber was adjusted to 30°C and 60% RH. This environment is considered typical of that likely to be encountered by soldiers operating in Townsville. Measurements were taken when the helmet laminate was:

- In contact with the hotplate surface.

- Suspended 20 mm above the hotplate surface by a fully enclosed spacer.

- Suspended 20 mm above the hotplate surface by a spacer with the front portion removed.

- Suspended 20 mm above the hotplate surface by a spacer with the rear portion removed.

- Suspended 20 mm above the hotplate surface by a spacer with both the front and rear portions removed.

2.3 Moisture Vapour Resistance (R_e)

The resistances of the helmet laminate to the transfer of moisture vapour were also measured using the sweating hotplate. These measurements were determined similarly to those for dry heat transfer except that the hotplate was operated in the sweating mode with a filter paper covering the hotplate surface. To guarantee that only moisture vapour and not liquid water contacted the sample being measured the filter paper was covered with a cellophane membrane. A sweat rate of 0.3 g m^{-2} s^{-1} was selected for all experiments which represented a level of moisture transfer that ensured the filter paper remained completely wet for the duration of the test and that the cellophane membrane did not dry out.

When testing for R_c and R_e care was taken to ensure the hotplate surface and guard ring was completely covered by the specimen being tested

2.4 Configuration of the Spacer

The thermal resistance (R_c) and resistance to the transfer of moisture vapour (R_e) of the helmet laminate were measured while:

- in contact with the hotplate surface
- supported 20mm above the hotplate surface on a foam spacer

When supported by the spacer measurements were taken with:
- a portion of the front of the spacer removed

- a portion of the back removed
- both the front and back removed.

The configuration of the spacers and the measured resistances to heat and moisture vapour are given in Table 1.

2.5 Configuration of the Laminate

The laminate was tested complete, then with three small holes drilled through its front surface. These holes removed 1% of the surface area. After each set of measurements the three holes were enlarged and the measurements repeated. The holes were enlarged four times. After the first enlargement 4% of the surface area was removed, after the second 15%, the third 20% and the final enlargement resulted in 30% of the surface area being removed.

2.6 Testing of the Ventilation of a Helmet using a Manikin

The effectiveness of air flow under the ADF helmet was measured in-situ using a manikin head. A manikin head fitted with a ballistic helmet was placed in a low speed wind tunnel and the velocity of the incident air and that flowing under the helmet was measured. Holes were drilled through the helmet to the right of the forehead, at the crown, above the right ear, at the top rear and at the lower left rear. The measuring probe from the air velocity meter fitted snugly through these holes with no apparent air leakage. The measurement holes were plugged using cork stoppers when not in use. The air velocity was measured at these locations at incident air speeds of 2.0 ms^{-1}, 1.6 ms^{-1}, 1.3 ms^{-1}, 1.0 ms^{-1}, 0.7 ms^{-1} and 0.5 ms^{-1}. Four helmet configurations were used, an unvented helmet, a helmet vented with two 50 mm wide and 5 mm high slots on each side of the front of the helmet equidistant from the centre and approximately 60 mm above the peak, a helmet with 50 mm wide and 5 mm high slots at the front and two identical sized slots diagonally opposite through the rear face of the helmet and a helmet with the front slots kept at 50 mm wide but with the height of the slots being increased to 20 mm while the rear slots remained at a height of 5 mm.

3. Results and Discussion

The ADF combat helmet consists of an outer shell manufactured using an aramid reinforced composite, which is similar in shape to the US PASGT helmet. It is anchored to the head using a sling system that provides a stand off distance from the head that varies between 20 mm and 25 mm depending on the location. The helmet is held in place by a chinstrap that is an integral part of the sling assembly. Although the main purpose of the stand-off distance is to protect the head from blunt trauma when the helmet receives impact from high-speed projectiles, an added benefit is that the dead air space between the head and the helmet can provide an avenue for the exchange of air by convection when walking or when there is a wind. Conversely if

the air within the space between the helmet and the head is held stationary it acts as a layer of insulation which adds to the thermal burden.

3.1 Thermal Transmission

3.1.1 R_c of the laminate measured while in contact with the hotplate surface

Measurements of the thermal resistance (R_c) of the helmet laminate while in contact with the hotplate surface show that the thermal resistance is unaffected until the amount of laminate removed exceeds 20%. This is clearly shown in Figure 3 where it can be seen that the R_c of the laminate varies between 0.03 m^2KW^{-1} and 0.04 m^2KW^{-1} when up to 20% of the laminate is removed, then decreases to below 0.03 m^2KW^{-1} when the amount removed is increased to 30%. A reduction in the R_c value indicates that heat can be removed from the source more readily. These measurements show that without any air gap between the laminate and the heat source a large amount of the surface area of the helmet must be removed as venting, before any benefit is apparent.

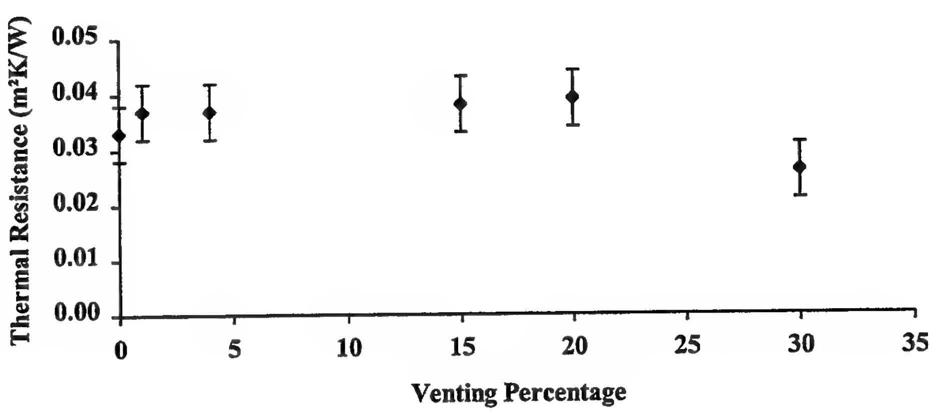


Figure 3 Thermal resistance of laminate whilst in contact with hotplate (error bars showing standard deviation).

3.1.2 R_c of the laminate measured while supported by a full spacer

The thermal resistance (R_c) of the laminate behaves differently when it is supported 20 mm above the hotplate surface by a fully enclosed spacer compared to when it is in direct contact with the surface of the hotplate. From Figure 4 it is clear that the R_c decreases linearly as the amount of ventilation is increased. When compared with the thermal resistances of the samples measured while in contact with the hotplate surface the R_c values of the laminates supported by the spacer are larger. This highlights the disadvantages of having air trapped between the surface of the hotplate and the underside of the laminate. As there is no air flow through the spacer the only avenue for heat to dissipate is by convection through the vent holes. Table 1 shows that under these conditions there is no significant advantage in having the laminate vented unless a minimum of 15% of the surface area of the laminate is

removed. Further advantages were observed as the amount of venting was increased to the maximum 30%.

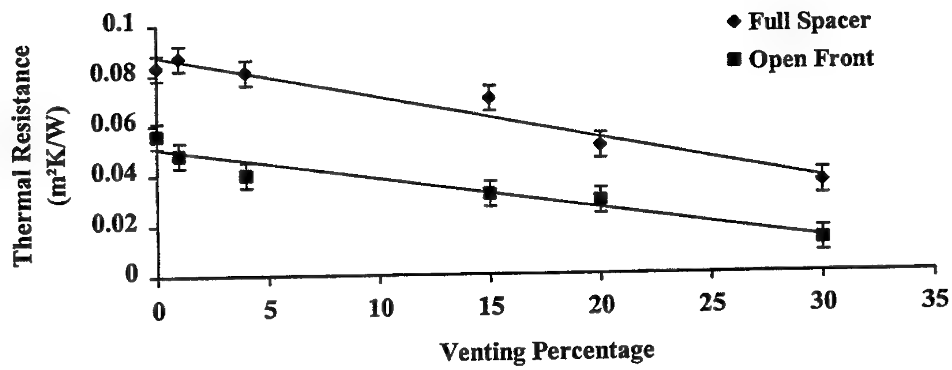


Figure 4 Thermal resistance of laminate whilst supported above hotplate (error bars showing standard deviation).

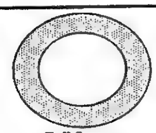
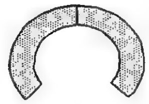
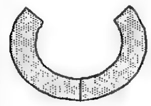
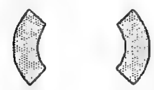
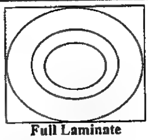
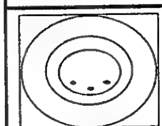
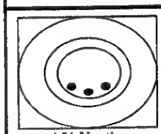
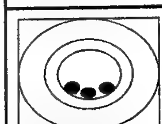
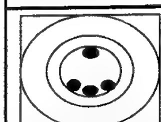
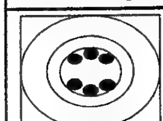
3.1.3 R_c of the laminate measured while supported by a spacer that is open at the front

Again the thermal resistance of the laminate decreases linearly as the amount of ventilation is increased. The opening at the front of the spacer reduces the R_c of the laminate at all standoff distances compared with the laminate supported by a full spacer. As can be seen from Table 1 the R_c of the laminate measured when in contact with the surface of the hotplate is 0.68 the value of that supported by a full spacer that is open at the front. When the 30% vented laminate is used this ratio falls to 0.36.

3.1.4 R_c of the laminate measured while supported by a spacer that is open at both the front and back.

The laminate showed no resistance to the flow of heat regardless of whether the laminate was vented or not. From Table 1 it can be seen that regardless of the amount of venting, the R_c values for the helmet laminate are almost identical in value to those of the hotplate with no laminate. These results demonstrate the importance of airflow over the surface of the heat source which appears to be more important than venting of the laminate.

Table 1 Configuration of the spacers and measured resistances to heat (R_c) and moisture vapour (R_e)

	In contact		Full Spacer 		Open Front 		Open Rear 		Open Front and Rear 	
	R_c m^2K/W	R_e m^2Pa/W	R_c m^2K/W	R_e m^2Pa/W	R_c m^2K/W	R_e m^2Pa/W	R_c m^2K/W	R_e m^2Pa/W	R_c m^2K/W	R_e m^2Pa/W
 Full Laminate	0.03	555.6	0.08	48.7	0.06	14.7	0.02	4.8	0.00	-1.3
 1 % Venting	0.04	467.7	0.09	63.1	0.05	19.0	0.02	4.2	-0.01	-1.3
 4 % Venting	0.04	122.6	0.08	54.3	0.04	15.2	0.03	6.2	-0.01	-0.9
 15% Venting	0.04	53.1	0.07	26.5	0.03	7.8	0.02	1.1	-0.01	-2.2
 20 % Venting	0.04	42.8	0.05	13.2	0.03	3.2	0.02	5.5	-0.01	-1.9
 30 % Venting	0.03	30.8	0.04	10.3	0.01	4.2	0.02	2.0	-0.01	-1.8

3.2 Moisture Vapour Transfer

3.2.1 R_e of the laminate measured while in contact with the hotplate surface

The R_e is a measure of the effectiveness of heat transfer through the evaporation of water. The lower the R_e the less the resistance to the evaporation of water vapour. Each gram of water evaporated carries with it approximately 2400 J of heat energy depending on the temperature. To maximise this cooling effect the system must be sufficiently permeable to allow all the evaporated moisture to diffuse to the atmosphere. As shown in Table 1, the measured resistance to the transfer of moisture vapour (R_e) of the helmet laminate while in contact with the hotplate surface, shows that with no venting the R_e value is large but reduces by 353% with just 4% venting. As the area of venting is increased above 4%, the R_e value decreases further although the decrease is not as dramatic as that from zero to 4% venting.

3.2.2 R_e of the laminate measured while supported by a full spacer

Like the thermal resistance (R_c) values, the resistance to the transfer of moisture vapour (R_e) values for the laminate behave differently when it is supported 20 mm above the hotplate surface by a fully enclosed spacer. Under these conditions the R_e value of the laminate with no venting is 49 $m^2Pa\ W^{-1}$ compared with a value of 556 $m^2Pa\ W^{-1}$ for the unvented laminate measured while in direct contact with the hotplate surface. This again demonstrates the importance of evaporation of moisture as a mechanism for cooling. Although a full spacer encloses the surface of the sweating hotplate, which is the heat source, moisture evaporates into the space between the hotplate surface and the underside of the laminate. A steady state is reached when the pressure within the space equals the vapour pressure of the water evaporating from the hotplate surface. Increasing the amount of venting disrupts this steady state and reduces the partial pressure within the space resulting in a greater rate of evaporation and a reduced R_e. This results in a decrease in the R_e values as the area of venting is increased.

3.2.3 R_e of the laminate measured while supported by a spacer that is open at the front

As expected the R_e values for the laminate supported by a spacer open at the front are less than those for the laminate supported by a full spacer. Table 1 shows that a minimum of 15% venting was needed before any significant difference between R_e measurements became apparent.

3.2.4 R_e of the laminate measured while supported by a spacer that is open at the rear

The R_c and R_e values for the laminates measured while supported by a spacer opened at the rear were less than those for the same laminate supported by the same spacer opened at the front. As the same spacer was used for each set of measurements it was assumed that these differences resulted from the airflow within the environmental cabinet. A visual comparison of the air current eddies between the two different tests was conducted using smoke generated from an incense stick. For these measurements the opaque laminate was replaced with clear perspex so that the smoke eddies were visible. There was an obvious difference between the movement of the smoke depending on whether the spacer was opened at the front or the rear. When the spacer is opened at the front, the smoke was observed to move in an anti-clockwise direction. The movement of the smoke was quite slow until it reached the opening where its velocity increased as it was drawn into the environment. When the spacer was reversed and opened at the rear the smoke moved in a clockwise direction. The smoke moved at a faster more constant rate than when the spacer was opened at the front. These visual observations were confirmed with airflow measurements taken at five sites around the perimeter of the laminate when supported by the spacer which was opened at the front and at the rear. Airflow measurements were taken in the airspace between the underside of the test specimen and the hotplate surface. Figure 5 shows the location on the laminate of the airflow

velocity probe for each measurement. Measurements were taken in the direction of the air current. As seen in Table 2 the measured air velocities support the visual observations and show that the air flow is faster when the spacer is opened at the rear. At this stage the reasons for the differences in air flow is assumed to be an experimental anomaly due to the air circulation within the environmental chamber.

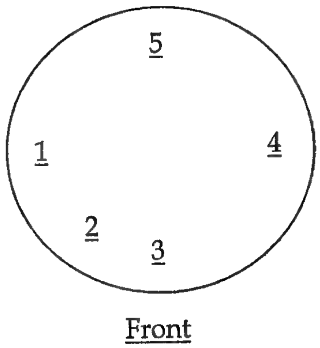


Figure 5 Location of Probes to measure the Airflow within the Environmental Chamber

Table 2 A & B Measured Velocities of Air under the Laminate

A. *Spacer with open front*

Probe number	1		2		3		4		5	
Direction of airflow	↓	←	↓	→	↓	→	↑	→	↑	←
Airflow (ms^{-1})	0.03	0.01	0.18	0.16	0.03	0.10	0.02	0.0	0.01	0.01

B. *Spacer with open rear*

Probe number	1		3		4		5	
Direction of airflow	↑	←	↓	←	↓	→	↑	→
Airflow (ms^{-1})	0.26	0.09	0.07	0.31	0.37	0.16	0.20	0.78

3.2.5 R_e of the laminate measured while supported by a spacer that is open at both the front and back.

The R_e measurements like the R_c measurements show that the most effective method for cooling the heat source is to support the specimen on a spacer that is opened at both the front and rear. Table 1 shows that there is no disadvantage in having a laminate covering the heat source on a spacer opened at both the front and rear compared with the heat source being completely bare. Translating these findings into

practice would suggest that a person could wear a helmet with minimal discomfort providing it had a standoff distance from the head (heat source) of 20 mm and that the helmet was ventilated at both the front and rear to allow air flow.

3.3 Helmet Ventilation using a Manikin

The sweating hotplate gives excellent comparative results for the resistance to the flow of heat and moisture for different spacer configurations. It shows that the best form of ventilation is a spacer that has in-line ventilation at the front and rear. These sweating hotplate results, however do not include convected or forced airflow across a head shaped surface. The measured airflows for the vented and unvented ADF helmet measured on a manikin torso are given in Table 3. At the higher air velocities (2.0 ms^{-1} and 1.6 ms^{-1}) the best cooled areas of the head were the crown and the upper rear. A reason for this is that the suspension system fits around the forehead and across the top of the head and this disrupts the airflow. In an attempt to overcome this the helmet was vented at the front and at the rear. The vents were kept in-line to simulate the flow-through ventilation, which was so effective when the helmet laminate was tested on the sweating hotplate and supported on a spacer that was vented at the front and rear.

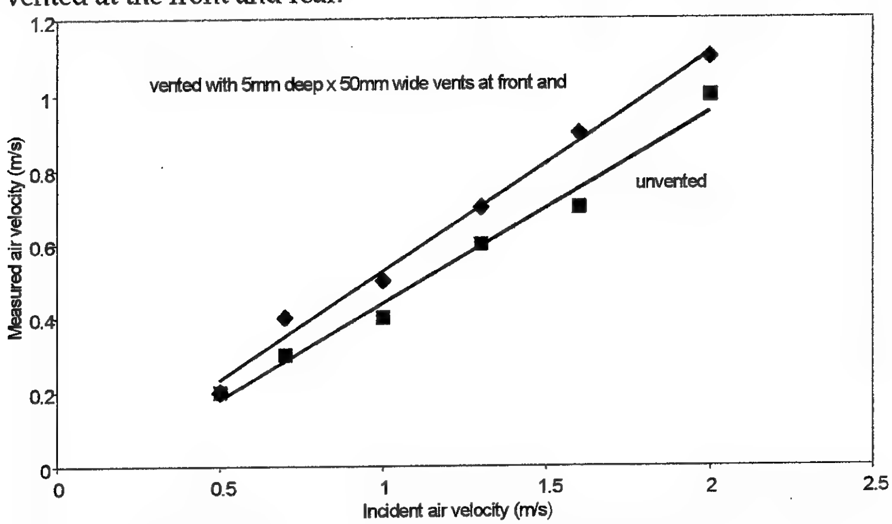


Figure 6 Change in Measured Airflow across the Crown for a Vented and Unvented Helmet

Figure 6 gives the measured changes in the airflow across the centre crown of the head with a change in incident air velocity. From Figure 6 it can be seen that, in general, an increase in the velocity of the incident air resulted in an increase in the flow of air across the head. There was little difference in the velocity of air flowing across the head when the helmet was vented with 50 mm wide and 20 mm deep vents in the front and 50 mm wide and 5 mm deep vents in the rear compared with the smaller 50 mm wide and 5 mm deep vents in the front and the same size vents in the rear. There was also very little difference between the unvented helmet and the vented versions. In some cases the unvented helmet outperformed the vented versions.

Table 3 Low speed wind tunnel: Helmeted manikin results

	Eye Level		Right Forehead	Centre crown	Above right ear	Upper rear right	Lower rear left
	150mm Average air Speed (m/s)	25mm Average air speed (m/s)	Average air Speed (m/s)	Average air speed (m/s)	Average air speed (m/s)	Average air speed (m/s)	Average air speed (m/s)
Unvented	2.0	1.2	0.3	1.0	0.2	0.9	1.0
Vented 2x(5x50mm) slots front	2.0	1.6	0.3	0.8	0.1	1.0	0.5
Vented 2x(5x50mm) slots front and rear	2.0	1.3	0.2	1.1	0.9	0.8	0.9
Vented 2x(20x50mm) slots front & 2x(5x50mm) slots rear	2.0	1.3	0.1	1.1	0.2	0.5	0.7
Unvented	1.6	1.0	0.2	0.7	0.3	0.8	0.8
Vented 2x(5x50mm) slots front	1.6	1.2	0.2	0.7	0.1	0.8	0.4
Vented 2x(5x50mm) slots front and rear	1.6	1.1	0.2	0.9	0.6	0.7	0.9
Vented 2x(20x50mm) slots front & 2x(5x50mm) slots rear	1.6	1.0	0.4	0.9	0.1	0.5	0.5
Unvented	1.3	0.7	0.1	0.6	0.1	0.5	0.5
Vented 2x(5x50mm) slots front	1.3	0.7	0.1	0.6	0.1	0.5	0.4
Vented 2x(5x50mm) slots front and rear	1.3	0.8	0.1	0.7	0.4	0.5	0.6
Vented 2x(20x50mm) slots front & 2x(5x50mm) slots rear	1.3	0.9	0.2	0.7	0.1	0.3	0.4
Unvented	1.0	0.7	0.1	0.4	0.2	0.5	0.5
Vented 2x(5x50mm) slots front	1.0	0.8	0.1	0.6	0.1	0.5	0.3
Vented 2x(5x50mm) slots front and rear	1.0	0.6	0.1	0.5	0.2	0.4	0.4
Vented 2x(20x50mm) slots front & 2x(5x50mm) slots rear	1.0	0.7	0.2	0.5	0.1	0.2	0.3
Unvented	0.7	0.4	0.1	0.3	0.1	0.4	0.3
Vented 2x(5x50mm) slots front	0.7	0.5	0.1	0.4	0.1	0.4	0.3
Vented 2x(5x50mm) slots front and rear	0.7	0.4	0.1	0.4	0.1	0.3	0.3
Vented 2x(20x50mm) slots front & 2x(5x50mm) slots rear	0.7	0.5	0.2	0.3	0.0	0.2	0.2
Unvented	0.5	0.3	0.0	0.2	0.0	0.2	0.2
Vented 2x(5x50mm) slots front	0.5	0.3	0.0	0.2	0.0	0.2	0.1
Vented 2x(5x50mm) slots front and rear	0.5	0.3	0.0	0.2	0.0	0.2	0.2
Vented 2x(20x50mm) slots front & 2x(5x50mm) slots rear	0.5	0.3	0.0	0.2	0.0	0.1	0.1

4. Conclusions

Measurements of the resistance of heat (R_c) and moisture vapour (R_e) for the helmet laminate were made using a sweating hotplate as the heat source. These results indicated that the most efficient means of reducing the R_c and R_e values was not by venting the helmet but by including an air gap between the laminate and the heat source. The most efficient air gap was found to be one that provided flow-through ventilation from the front to the rear.

The sweating hotplate results were translated into practice by measuring the airflow under a helmeted manikin placed in low velocity airstreams. These results, like those from the sweating hotplate showed that in terms of wearer comfort there is little benefit in venting the helmet unless a large amount of the helmet surface is removed. Most likely this would have an adverse affect on the integrity of the helmet and reduce its ability to provide the ballistic protection for which it was designed.

Members of the ADF intuitively thought that venting the ADF ballistic helmet with small vent holes would provide a large increase in wearer comfort. This has been shown to be unlikely given that little thermal benefit results from a small amount of venting. It has been demonstrated that a suitable method for reducing the thermal burden imparted by a helmet is by encouraging an airflow under the helmet and across the crown. Research into a more effective method for mounting the helmet on the head to assist this airflow would be more beneficial than venting the helmet.

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G. T. Egglestone and D. J. Robinson

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19. ABSTRACT

Ballistic helmets are designed primarily to protect the head against high-speed impact from fragmentation munitions. The Australian Defence Forces (ADF) have recently introduced into service a composite ballistic helmet. This ballistic helmet is similar in shape to the US Army PASGT helmet on which it is based. When designing these ballistic helmets scant attention was given to the thermal loading on the wearer. Laboratory trials however, have shown that some soldiers have experienced "hotspots " on the front of the head when wearing the ADF ballistic helmet in hot environments.
The ballistic helmet is an integral component of the personal armour system and must be worn when wearing a fragmentation or ballistic vest regardless of the environmental conditions. In order to reduce the thermal loading, venting of the helmet was proposed. This report examines airflows under a ballistic helmet and the effect of venting on thermal and vapour resistances using a sweating hotplate. From this work venting does not appear to provide an adequate solution to reducing the thermal load imposed by a ballistic helmet.